45th International Conference on Environmental Systems

Thermal Analysis of the Iodine Satellite (iSAT)

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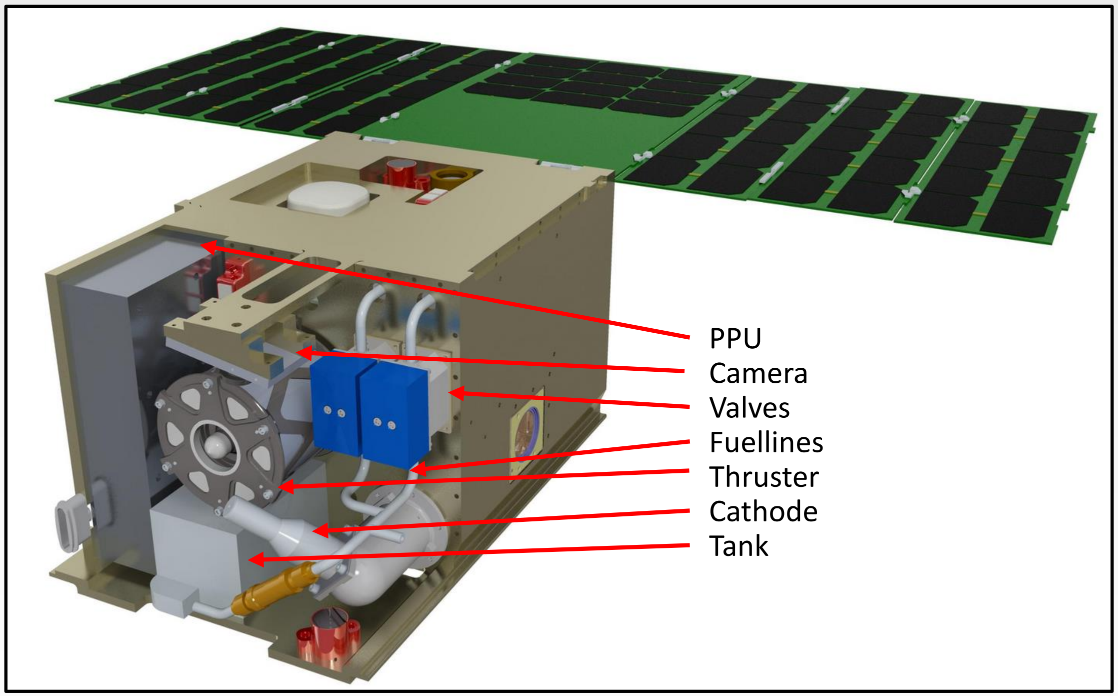
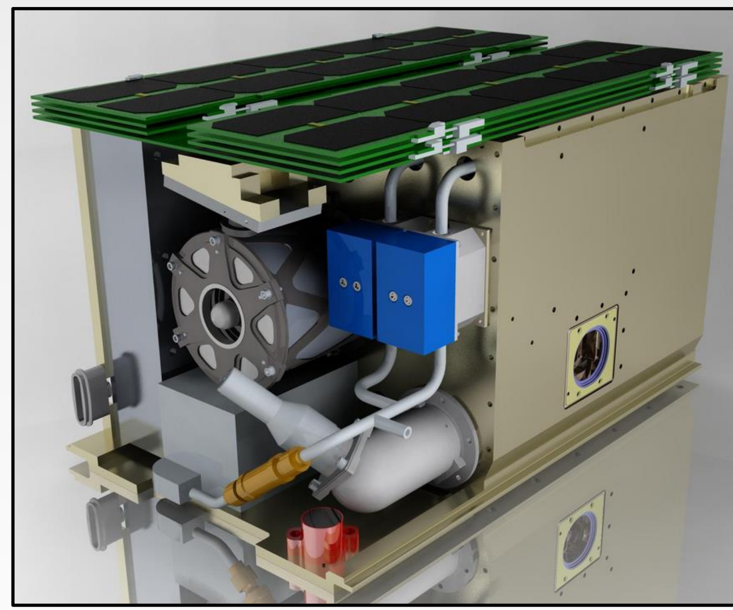
Outline

- Why iSAT?
- What is iSAT?
- iSAT Environments
- Challenges
- Thermal Model
- Evolution: Initial Study – DAC1 (PDR Model)
- PDR Model
- PDR Model Results
- Evolution: DAC2 – DAC3 (CDR Model)
- DAC2 Results
- Current Design *(Not included in paper)*
- Current Thermal Model *(Not included in paper)*
- Solutions to Challenges
- Key Takeaways

What is iSAT?

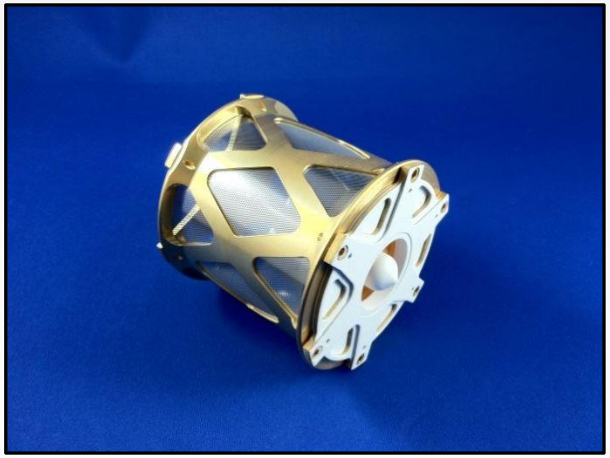
- 12U Cubesat

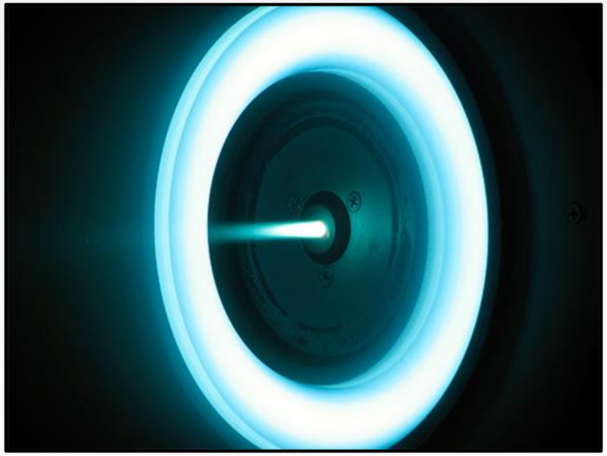




Why iSAT?

- Further technology of cubesat propulsion
- Iodine provides high thrust-to-mass ratio
- Iodine can be stored as a solid at low pressure and sublimated to a gas for use as fuel



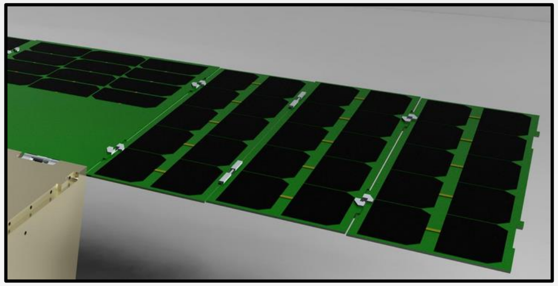


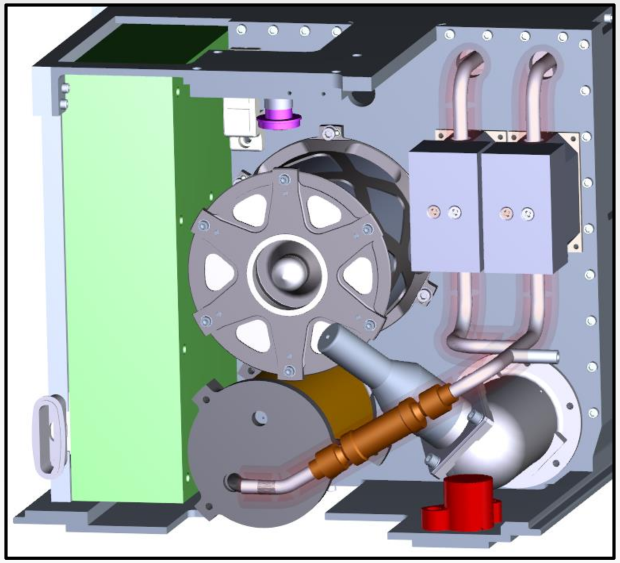
iSAT Environments

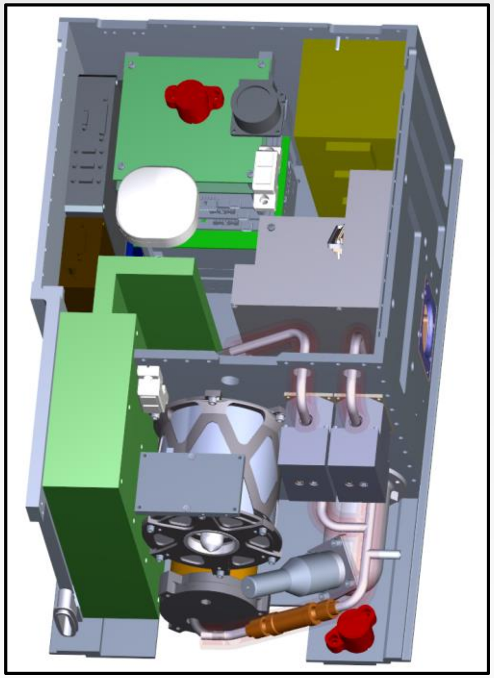
- Unknown launch vehicle and launch date
- Unknown orbit
- Bracketed Orbits:
  - Hot environment: Full Sun, beta=90°, minimum altitude
  - Cold environment: Maximum eclipse, beta=0°, maximum altitude

Challenges

- Power
- Heat
- Volume

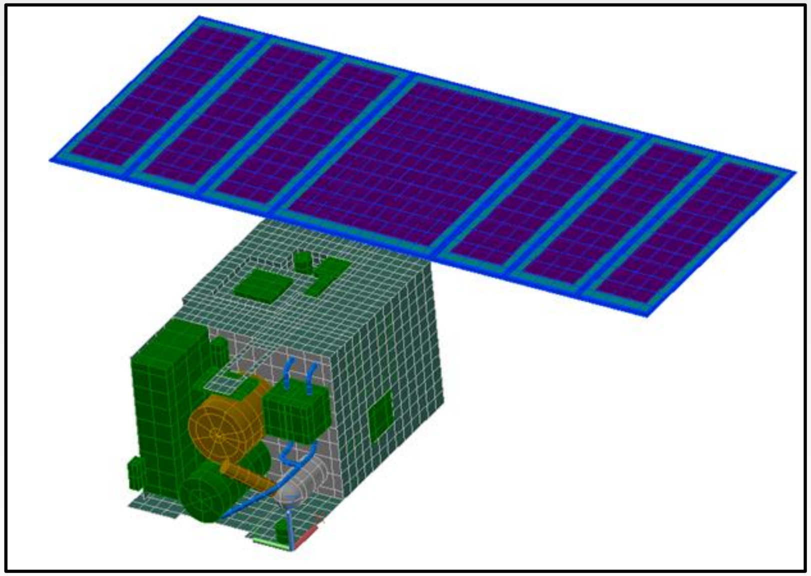




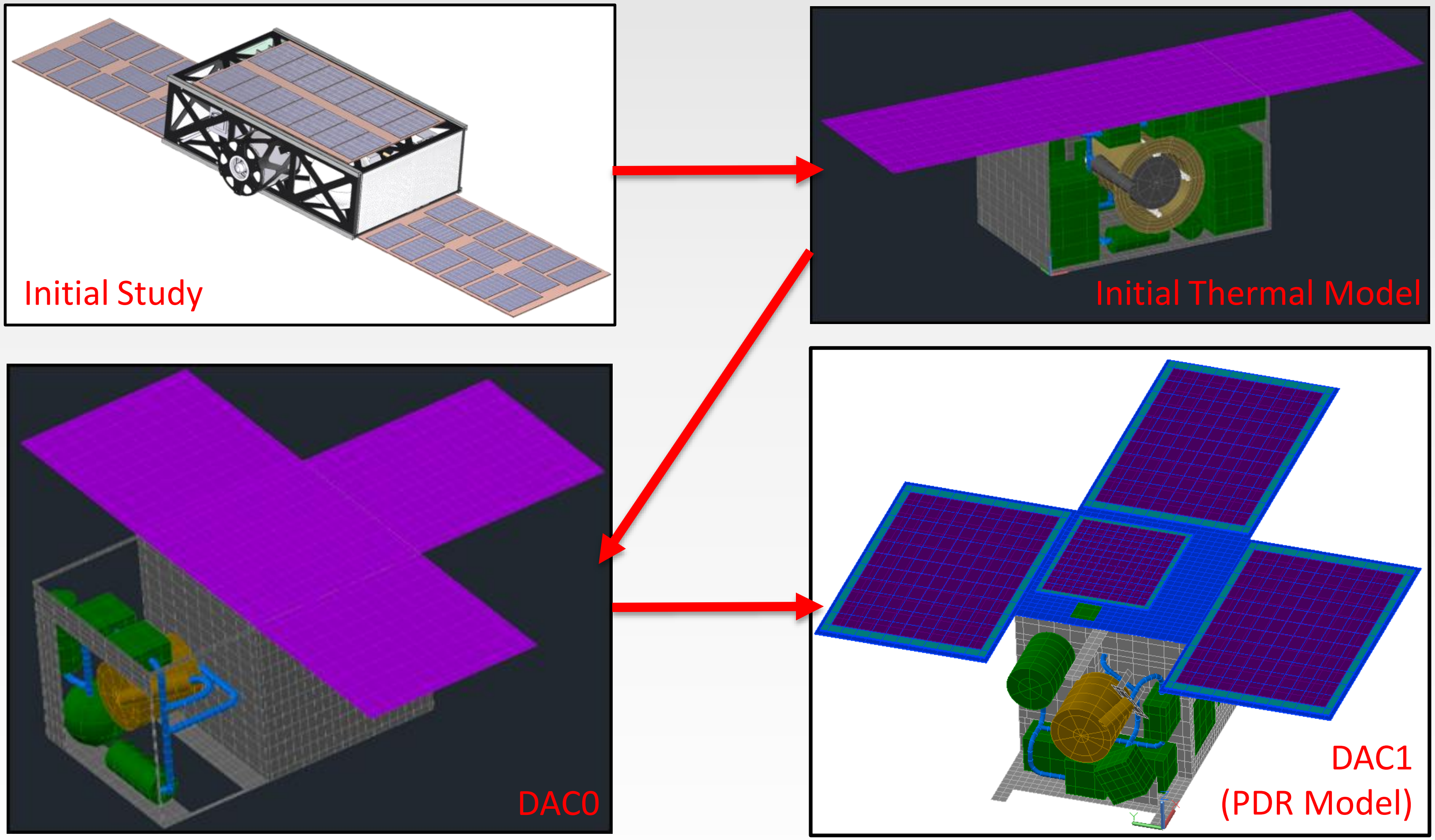


Thermal Model

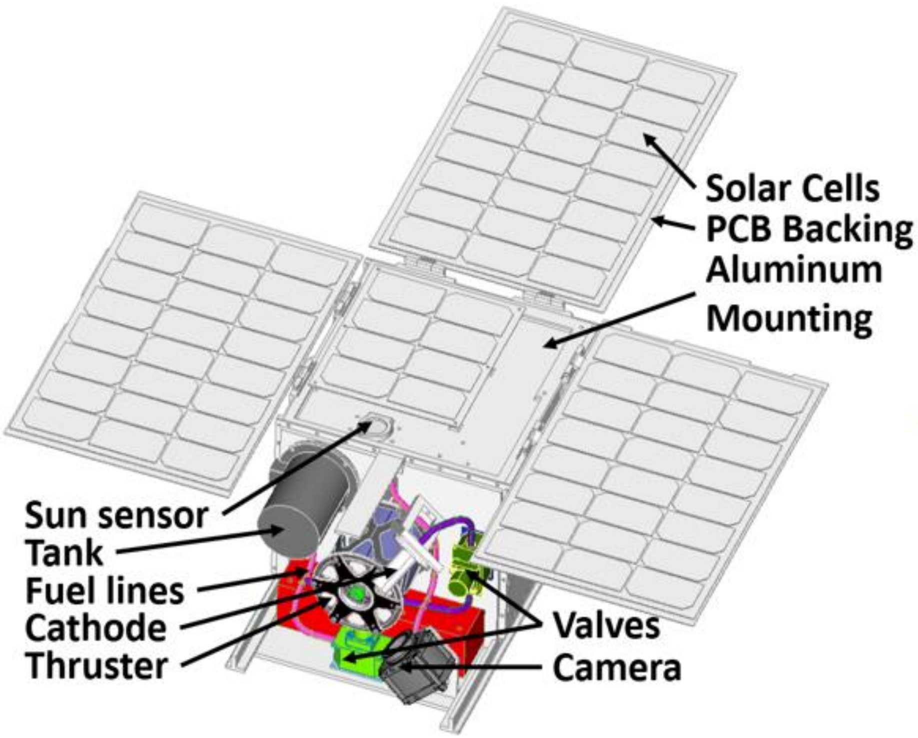
- Thermal Desktop 5.6 Patch 8, SINDA/FLUINT 5.5 Patch 11
- Challenges
  - Component fidelity
  - Unknown contact values
  - Bracketed orbits
  - Rapid changes
  - Unknown components
    - COTS vs in-house
    - Changing components

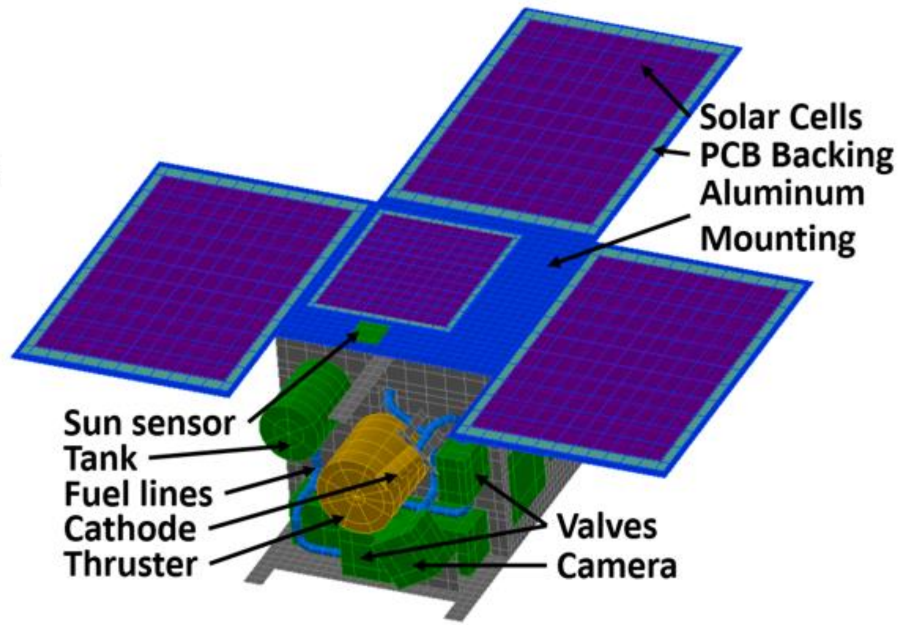


Evolution



PDR Model


Solar Cells
PCB Backing
Aluminum
Mounting
Sun sensor
Tank
Fuel lines
Cathode
Thruster
Valves
Camera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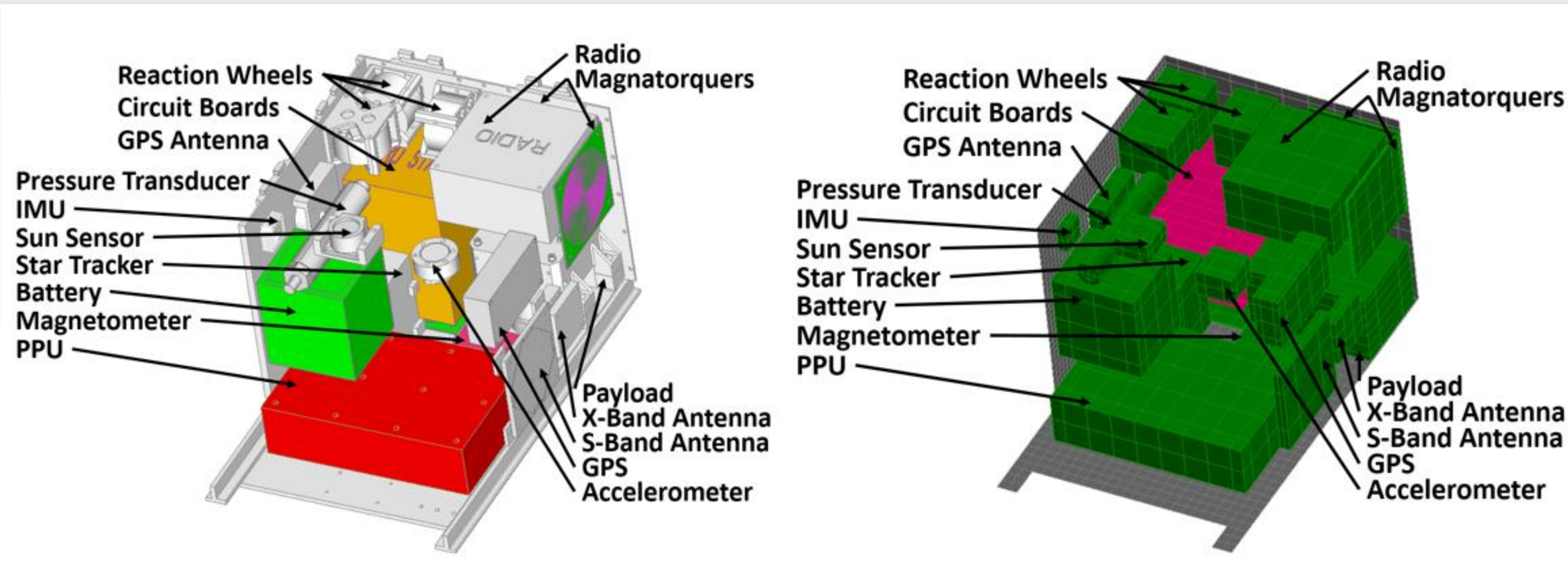
PDR Model


Reaction Wheels
Circuit Boards
GPS Antenna
Pressure Transducer
IMU
Sun Sensor
Star Tracker
Battery
Magnetometer
PPU
Radio
Magnatorquers
RADIO
Payload
X-Band Antenna
S-Band Antenna
GPS
Accelerometer
Reaction Wheels
Circuit Boards
GPS Antenna
Pressure Transducer
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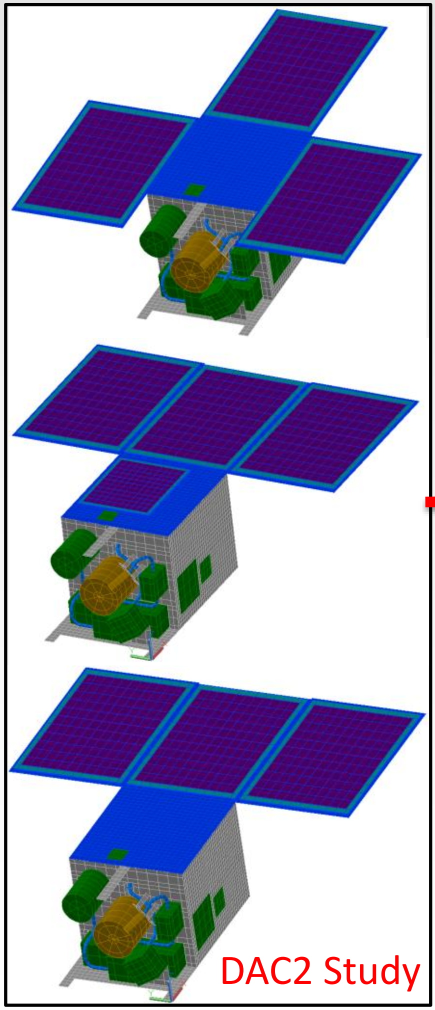
Sun Sensor
Star Tracker
Battery
Magnetometer
PPU
Radio
Magnatorquers
Payload
X-Band Antenna
S-Band Antenna
GPS
Accelerometer

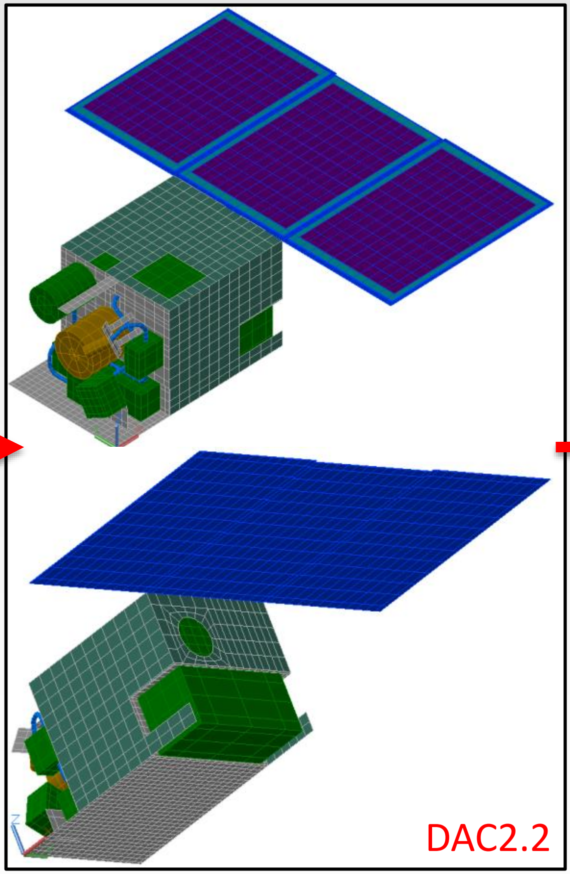
PDR Model Results

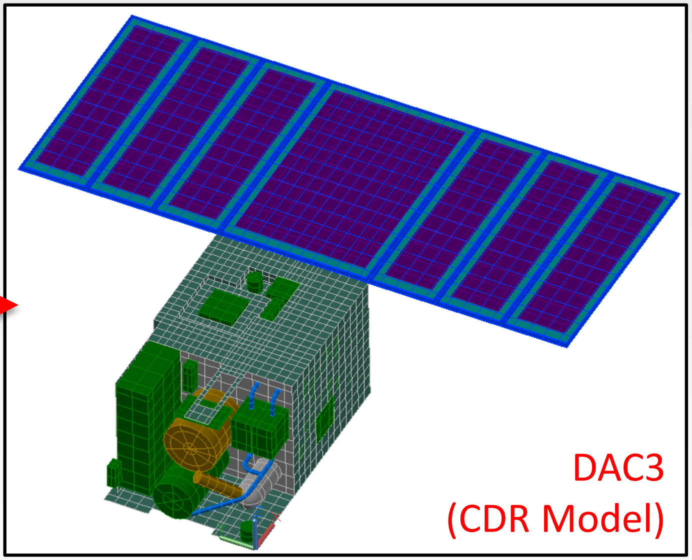
- Maximum Temperature of any phase modeled

Subsystem	Component Name	Max Survivability Temperature (C)	Max Operational Temperature (C)	Max Predicted Temperature (C)
Power	PMB	85	85	83
Power	PDB	85	85	84
C&DH	FC	70	60	59
Propulsion	PFCVs (heater)	150	130	164
Propulsion	PT (heater)	100	100	109
Propulsion	Fuel Lines (heater)	150*	150*	198
Propulsion	Fuel Lines Insulation	200*	200*	197
Payload	IR Camera	70	20	36
Power	Battery	60	60	53
Structure	Chassis	120	120	60, 164

Evolution



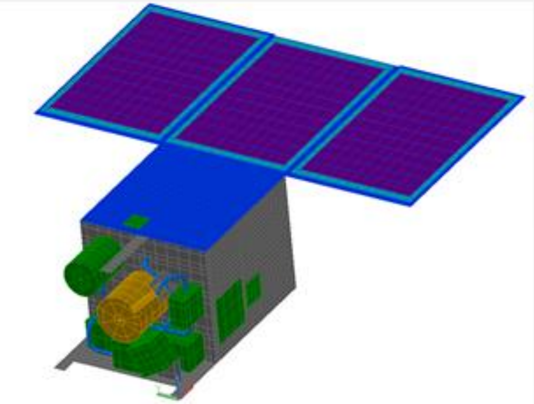




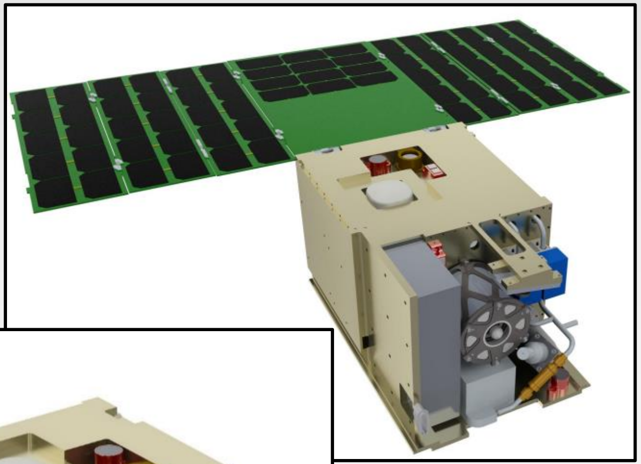
DAC2 Results

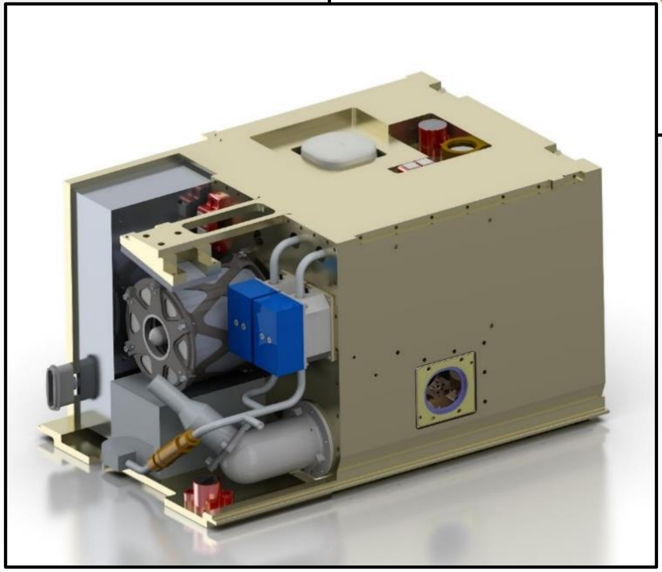
- Maximum Temperature of Altitude Reduction phase

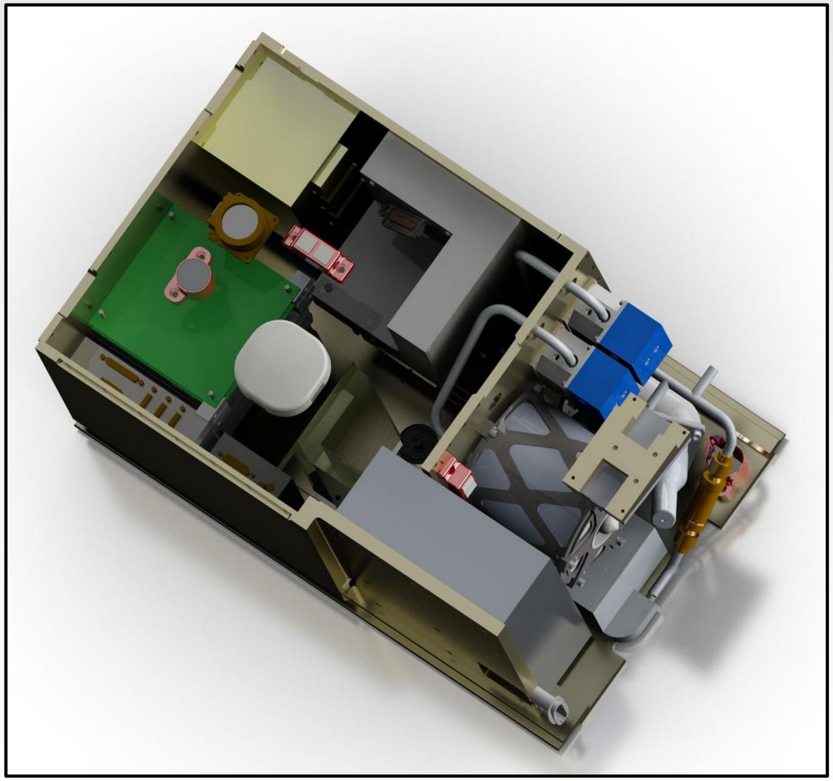
Subsystem	Component Name	Max Survivability Temperature (C)	Max Operational Temperature (C)	Maximum Analysis Temperature (C)	
				DAC1	DAC2
Power	PMB	85	85	79	62
Power	PDB	85	85	76	58
C&DH	FC	70	60	55	39
Propulsion	PFCVs (heater)	150	130	162	124
Propulsion	PT (heater)	100	100	109	93
Propulsion	Fuel Lines (heater)	150*	150*	198	141
Propulsion	Fuel Lines Insulation	400	290	197	140
Payload	IR Camera	70	20	32	16
Power	Battery	60	60	43	19
Structure	Chassis Main… Cathode Mount	120*	120*	56… 124	35, 104



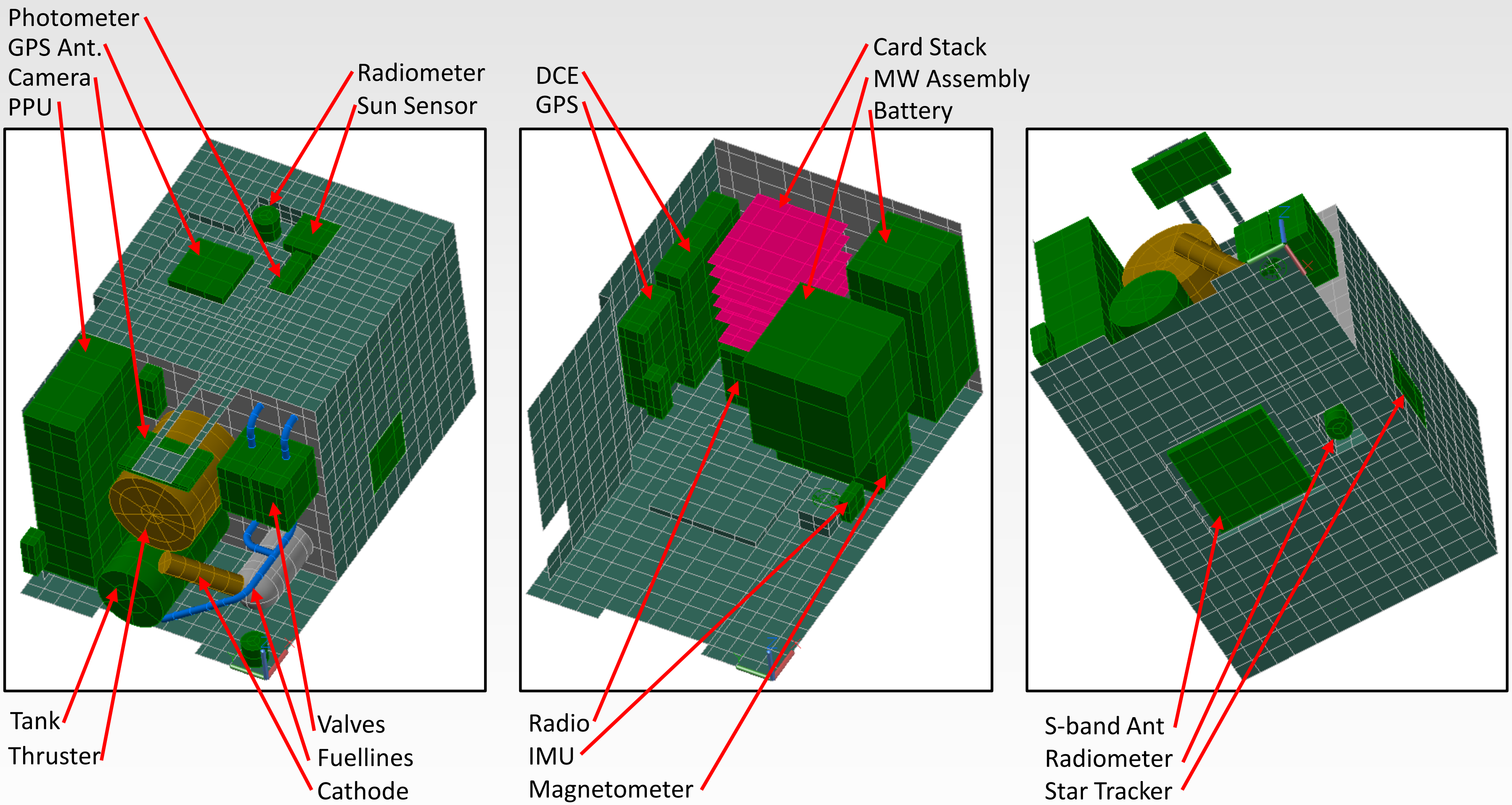
Current Design







Current Thermal Model



Solutions to Challenges

- Power
  - Deployable solar panels
  - Alter con-ops to thrust less often
- Heat
  - Propulsion components are exposed to space
  - Isolate heated propulsion components
    - Insulation
    - Stand-offs between non-heated components
  - Entire chassis is covered in silver Teflon tape, acts as radiator
  - Reduce heat transfer from solar panels to chassis body
  - Alter con-ops to not continuously heat components
  - Utilize heat strap from flight computer
- Volume
  - Reduce number of “unnecessary” components

Key Takeaways

- Cubesat challenges
  - Power
  - Thermal
  - Volume
  - Environments
- Modeling challenges
  - Unknowns / evolving design
  - Fidelity
  - High rate of changes: Symbols and parameterization have been useful modeling tools.
- Thermal concerns not needing consideration on larger space crafts may be bigger concerns on a cubesat

Questions?